tentamen ta3220: Fluid flow, heat and mass transfer
9.00-12.00 uur, 16 januari 2004, TA Gebouw

Flow: Oil-water separation *(20 marks)*

The dimensions of a horizontal channel in an oil-water separator are 2.50 m (length), 1.00 m (width) and 1.20 cm (height). Through the channel water, containing a very low concentration of small oil droplets, is flowing. The average velocity of the oil-water mixture is 1.86 cm/s. Specific masses of oil and water are, respectively, 885 and 1000 kg/m^3. The dynamic viscosity of water is 0.00095 Pa.s, and the acceleration of gravity is 9.80 m/s^2.

Questions:

(1) Calculate the critical oil droplet diameter (in micrometers).

(2) Demonstrate that the flow in the separator channel is laminar.

(3) For which oil droplet diameter is valid that the droplet Reynolds number is 1?

Heat transfer: Pipe insulation ***(20 marks)***

A cast iron steam pipe of 0.11 m O.D. and 0.10 m I.D. carries steam at 200°C. It is to be insulated with a 0.025 m thick of insulating material of k_m=0.035 W/m·K. the ambient temperature is 0°C and the outer and inner heat transfer coefficients are 75 and 225 W/m^{2}K, respectively.

Question:

(1) Show that heat flux through the wall of the pipe is less when the insulation is placed on the inner surface than when it is placed on the outer surface.

(2) What thickness of insulation, when placed on the outer surface, gives the same heat flux through the wall as a 0.025-m thickness placed on the inner wall?

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Mass Transfer: Deoxidation of liquid copper *(20 marks)*

Copper is deoxidized by bubbling methane gas through it. If it can be assumed that it takes a bubble 0.1 seconds to reach the top of the copper bath and that 50Nm^3/h of gas is used, how long will it take to reduce the oxygen concentration in 100t copper by 90%? All the required data are given below.

Please give reasons for all assumptions you make in your calculations.

Data